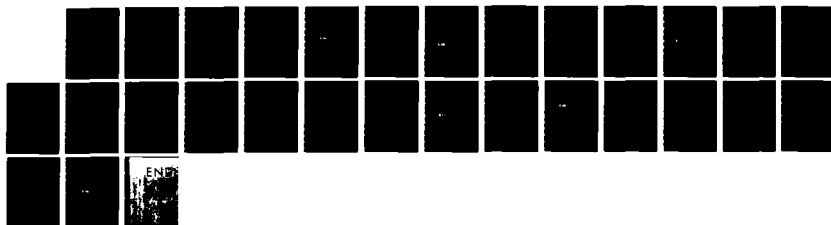


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ESTIMATES OF BOTTOM LOSS UPGRADE GEOACOUSTIC PARAMETERS 1/1  
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**ESTIMATES OF BOTTOM LOSS UPGRADE  
GEOACOUSTIC PARAMETERS AT THREE LOCATIONS  
IN THE SOUTH ATLANTIC**

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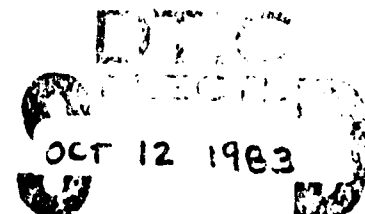
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Technical Report

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## I. BACKGROUND

The objective of the Bottom Loss Upgrade Program (BLUG), co-sponsored by the NORDA SEAS and TAEAS programs, is to increase the accuracy of low frequency acoustic predictions made by Fleet Numerical Oceanographic Center (FNOC) through an improved treatment of the acoustic interaction with the ocean floor. This objective is being achieved by replacing the limited set of bottom loss classes by a database containing a simplified set of geoacoustic parameters describing the ocean floor. Use of the BLUG database by suitably modified FNOC software will allow more accurate modeling of the effect of the ocean floor on both the amplitude and phase of the acoustic signal as well as providing dependence on frequency, grazing angle, and location in greater detail than currently possible. It is expected that the initial BLUG parameter values will be changed as new acoustical and geological data becomes available for analysis. The number and kind of geoacoustic parameters used in the BLUG profile are also expected to change in response to new research results, which will allow more complex bottom structures and higher frequencies to be treated accurately.

As a result of the NAVELEX 612 Exploratory Development Bottom Interaction Program, the geoacoustic profile is now generally accepted as the most flexible and useful means of characterizing the interaction of sound with the seafloor. Given the complete geoacoustic profile (the depth dependent density, velocity, and attenuation structure of the seafloor), it is theoretically possible to accurately predict bottom interaction effects on acoustic propagation. In practice it may not be necessary to use the complete geoacoustic profile; a simplified profile may adequately characterize the major acoustic processes needed for adequate acoustic predictions.

The BLUG geoacoustic profile is a simplified profile based on recent research that has developed an understanding of the major processes governing low frequency bottom interaction in areas of thick sediment cover in deep water environments. The successful analysis and interpretation of acoustic data from the BEARING STAKE exercise,<sup>1-3</sup> carried out by ARL:UT, used a fairly simple geoacoustic profile containing the surficial sediment density and the depth dependent compressional wave velocity and attenuation. Results from the NAVELEX 612 Bottom Interaction Program have provided a firm theoretical foundation for the use of this profile at low frequencies in areas of thick, unlayered sediment cover by showing that complications due to shear wave excitation in the sediment,<sup>4-5</sup> roughness of the sediment surface,<sup>6</sup> density gradients in the sediment,<sup>7</sup> and the properties of the substrate<sup>8</sup> do not have a major impact on low frequency acoustics in areas of thick unlayered sediment cover. Other work from the Bottom Interaction Program to establish values and empirical relations among geoacoustic parameters<sup>9</sup> has successfully provided estimates of these parameters that are consistent with those obtained from analysis of acoustic data. The BLUG profile is based on this scientific foundation and is expected to achieve the program goals in areas of thick sediment cover.

As a result of the work carried out at ARL:UT, primarily through the NAVELEX 612 Bottom Interaction Program, one of the recognized deficiencies of the simplified BLUG profile is its inability to accurately represent the low frequency acoustics of areas with thin sediment cover. In particular, the effects of sediment shear wave excitation, interaction with the basalt substrate, and scattering from the rough basement are not modeled in a realistic fashion by the initial BLUG parameter set. They are currently included through an empirical basement reflectivity parameter which is assumed to be independent of frequency and grazing angle.

Other recognized deficiencies in the initial BLUG database are the treatment of shallow water areas and the treatment of the anomalously

low bottom loss areas found primarily in the North Atlantic Ocean. Work is in progress within the NAVELEX 612 Bottom Interaction Program to develop the technical base needed to improve treatment of these areas in future upgrades of the BLUG database. At ARL:UT work is in progress to identify the major acoustical processes in shallow water areas and to determine the causes of the anomalously low loss such as near-surface layering<sup>10</sup> and hydrated marine sediments.<sup>11</sup>

The initial emphasis of the BLUG project has been to develop the geoacoustic database for the Northern Hemisphere for which there is much archived acoustic data. Studies of the Southern Hemisphere will rely mainly on geological analyses until significant quantities of acoustic data become available.

Any acoustic data currently available from the South Atlantic is an important resource for BLUG. In FY 82 ARL:UT was involved in the analysis of acoustic data from the SOUTHLANT 81 exercise. This data was processed to provide bottom loss at three sites in the South Atlantic Ocean.

This report presents estimates of the BLUG geoacoustic profiles for three SOUTHLANT 81 sites. To produce these profiles, the ARL:UT bottom loss measurement simulator used in earlier analyses was modified to be consistent with the ARL:UT data processing procedures. The simulator was then used to determine the BLUG parameters through a comparison of predicted and measured bottom loss. Because the data do not cover the crucial grazing angle range from  $0^{\circ}$  to  $30^{\circ}$ , the BLUG parameters could only be crudely estimated from the acoustic data. Geological data from Deep Sea Drilling Project (DSDP) sites in the exercise area were also used in estimating the BLUG parameters.

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## II. BLUG GEOACOUSTIC PARAMETERS

The BLUG geoacoustic profile contains nine parameters. Five of these parameters are needed to adequately describe thick sediment layers at low frequencies: the surficial density, sound speed gradient, compressional wave absorption, gradient of absorption, and ratio of sound speed to bottom water velocity. Given these parameters and the bottom water velocity, the major acoustical processes occurring in thick sediment layers can be adequately modeled. A sixth parameter is related to the curvature of the sound speed profile in the sediment and provides more accurate treatment of higher grazing angles.

The remaining three BLUG geoacoustic parameters are empirical in nature and are not at this time directly related to any known sedimentary features. They provide the flexibility needed to model bottom loss data from thin sediment areas<sup>12</sup> (such as vast areas in the Pacific) and the anomalously low loss areas<sup>13</sup> found primarily in the Atlantic.

The interaction with the basement, a dominant process in thin sediment areas, is included through an empirical basement reflectivity assumed to be independent of grazing angle and frequency. This form of the basement interaction does not adequately model the known acoustical processes of shear wave generation or scattering at the substrate. It may in fact lead to acceptable modeling of bottom loss data, but its relation to geological features is not known. This lack of acoustical or geological foundation brings into question the geographic extrapolation of this parameter.

The remaining two parameters are the empirically determined thickness and density of the surface layer needed in the BLUG profile to

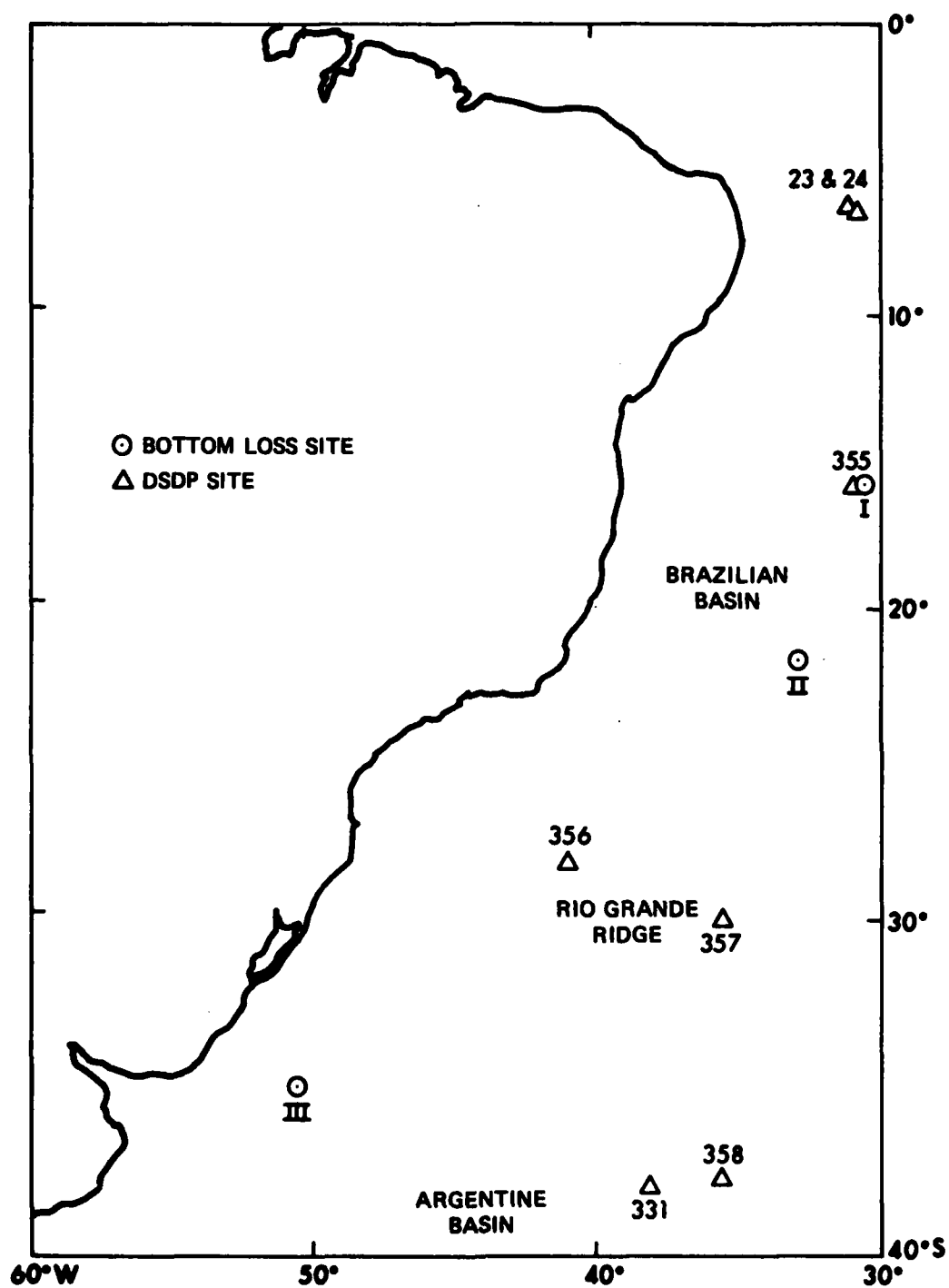
model bottom loss from low loss, thick sediment areas. The BLUG profile gives the sound speed of this layer equal to the surficial sound speed. The empirical nature of these parameters again raises questions concerning their geographic extrapolation. The large values of density needed have further reinforced their empirical nature, since they are clearly not related to geologically expected material.

### III. BLUG GEOACOUSTIC PARAMETERS AT THREE LOCATIONS IN THE SOUTH ATLANTIC

The SOUTHLANT 81 exercise, sponsored by the NORDA SEAS program, collected bottom loss data at the three locations in the South Atlantic shown in Fig. 1. Shot data were analyzed by ARL:UT using standard processing procedures described in detail elsewhere.<sup>2</sup> The data bandwidth supported processing to produce bottom loss curves from 50 to 500 Hz. The resulting 1/3 octave averaged bottom loss curves were then used as acoustic data for evaluating the BLUG geoacoustic parameters. We note that the data does not cover grazing angles from  $0^{\circ}$  to  $30^{\circ}$ . Also shown in Fig. 1 are DSDP sites that were used to obtain initial estimates for the BLUG parameters.

The procedure<sup>12</sup> used by ARL:UT to determine the BLUG geoacoustic parameters through a comparison of measured and predicted bottom loss could not be used with the SOUTHLANT 81 data. The measured bottom loss at low grazing angles, not covered in SOUTHLANT 81, is crucial<sup>13</sup> for determining several BLUG parameters, particularly the attenuation parameters and sound speed gradients. Geological data from DSDP sites in the exercise area (Fig. 1) and the empirical relations of Hamilton<sup>9</sup> became the primary resources for estimating BLUG parameters. The ARL:UT bottom loss measurement simulator, described in detail elsewhere,<sup>12</sup> was modified to incorporate a coherent reference loss consistent with the ARL:UT bottom loss processing procedure. The estimated BLUG geoacoustic profiles were then used with the simulator to predict bottom loss for comparison with the 1/3 octave averaged data. This comparison provides a qualitative check on the accuracy of the estimated BLUG parameters.

Table I contains the estimated BLUG geoacoustic parameters for the three SOUTHLANT 81 locations in Fig. 1. Figures 2-4 compare simulated



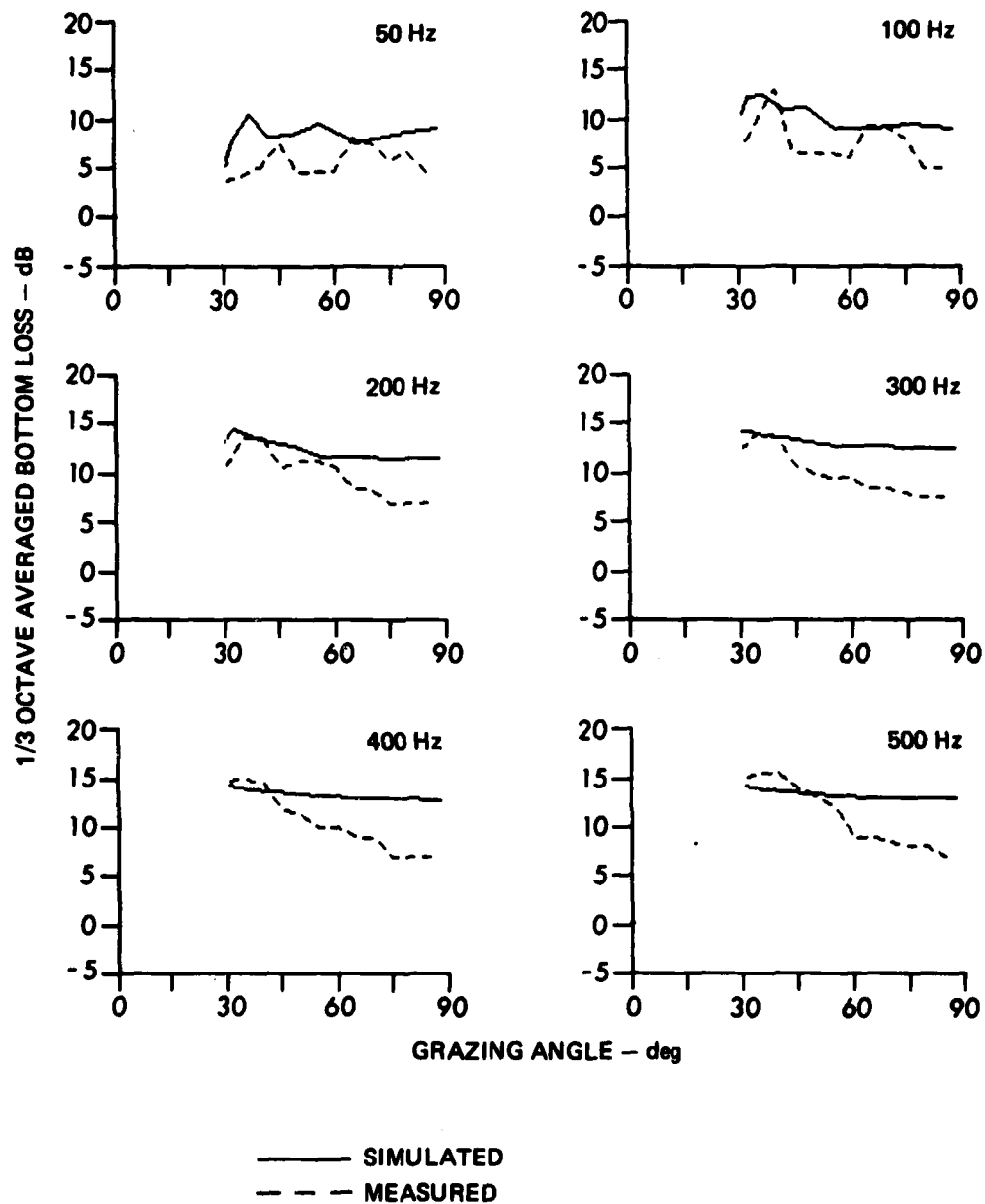
**FIGURE 1**  
**SOUTHLANT 81 EXERCISE AREA**

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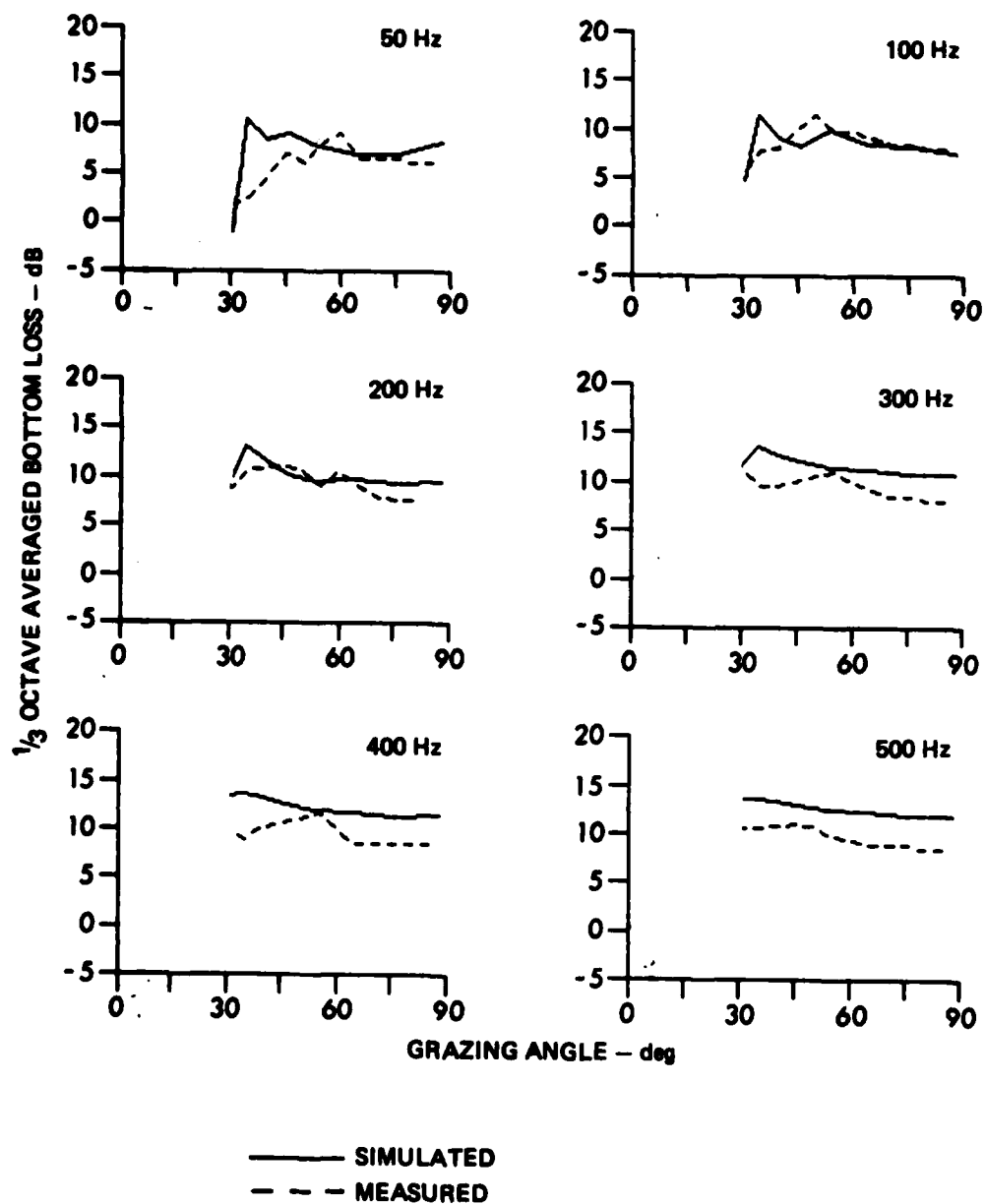
TABLE I  
BLUG GEOACOUSTIC PARAMETERS FOR THREE SITES  
IN THE SOUTH ATLANTIC OCEAN

<u>Parameter</u>	<u>Site 1</u>	<u>Site 2</u>	<u>Site 3</u>
sediment velocity/water velocity	0.976	0.982	0.980
sediment density (g/cm <sup>3</sup> )	1.67	1.67	1.67
surficial attenuation (dB/m-kHz)	0.001	0.001	0.001
attenuation gradient (dB/m <sup>2</sup> -kHz)	0.00022	0.000087	0.000013
sound speed gradient (sec <sup>-1</sup> )	1.3	1.3	1.3
curvature parameter	-0.5	-0.5	-0.5
surface layer thickness (m)	0.0	0.0	0.0
surface layer density (g/cm <sup>3</sup> )	---	---	---
basement reflectivity	0.50	0.50	0.50
sediment thickness (m)	449	449	741
water depth (m)	4860	4425	3500
bottom water velocity (m/sec)	1537	1527	1512



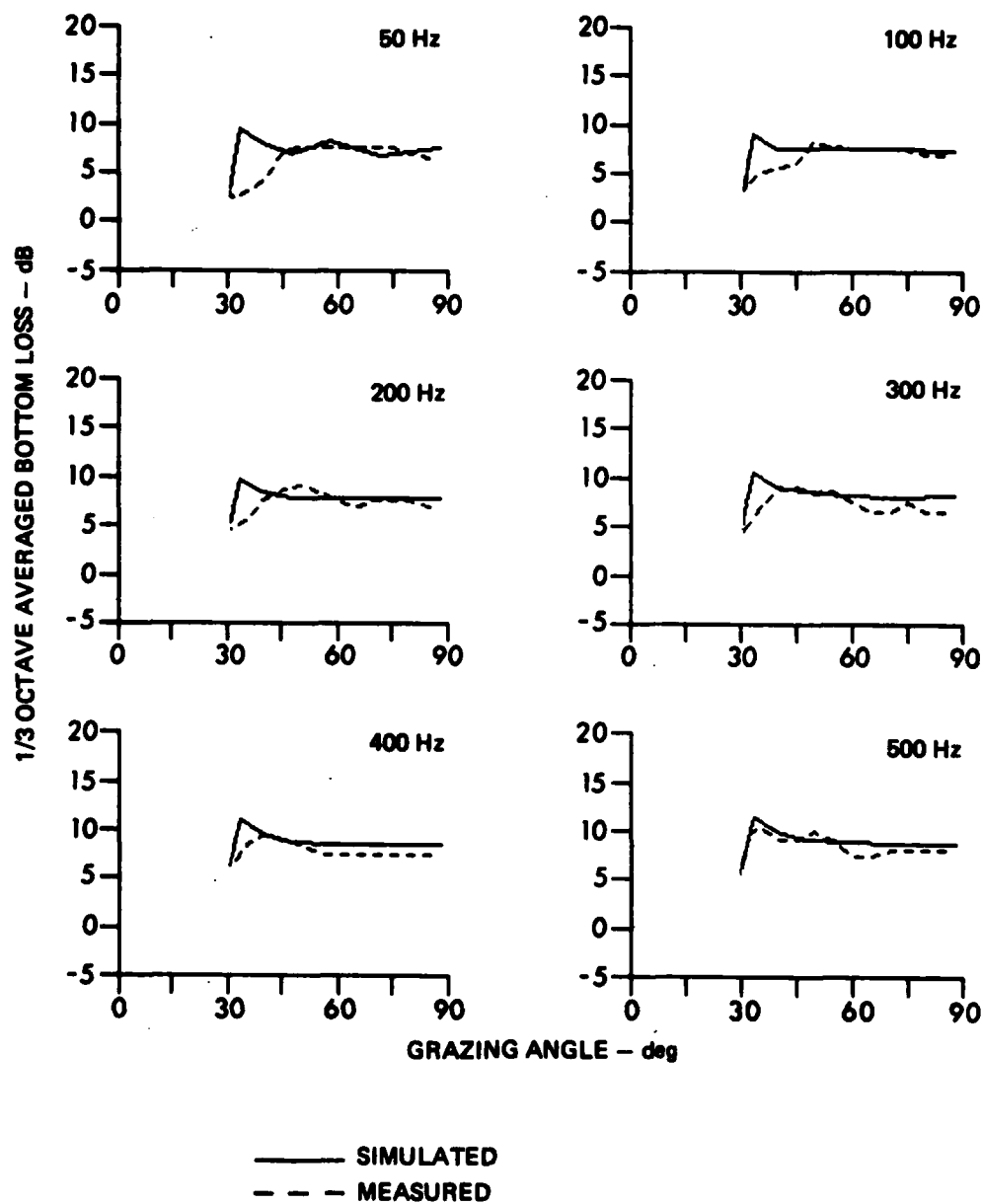
**FIGURE 2**  
**A COMPARISON OF MEASURED AND SIMULATED**  
**BOTTOM LOSS AT SITE 1**

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**FIGURE 3**  
**A COMPARISON OF MEASURED AND SIMULATED**  
**BOTTOM LOSS AT SITE 2**

ARL:UT  
 AS-83-080  
 PJV - GA  
 8 - 24 - 83



**FIGURE 4**  
**A COMPARISON OF MEASURED AND SIMULATED**  
**BOTTOM LOSS AT SITE 3**

ARL:UT  
 AS-83-981  
 PJV - GA  
 8 - 24 - 83

and measured bottom loss. The comparison at sites 2 and 3 is excellent, while that at site 1 is poor at large grazing angles. At  $30^{\circ}$ , the lowest angle at which data is available, attenuation of the sediment penetrating energy is noticeable. The increase in both measured and predicted loss with frequency at  $30^{\circ}$  shows that the estimated attenuation values in Table I are reasonable.

No attempt was made to improve the fit to the data by introducing a BLUG surface layer. This thin surface layer is included in the BLUG geoacoustic profile to increase reflectivity at higher frequencies<sup>13</sup> (above 400 Hz). Since the SOUTHLANT 81 data is predominantly at lower frequencies, a surface layer would have negligible acoustical effect.

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#### IV. SUMMARY

BLUG geoacoustic parameters were estimated for three sites in the South Atlantic Ocean. Parameter values had to be derived primarily from geological data because no acoustic data were available at low grazing angles ( $<30^{\circ}$ ). The available acoustic data were used as a qualitative check on the estimated values of the BLUG parameters. The lack of high frequency and low angle acoustic data restricts the use of these parameters to the 50-500 Hz frequency range and  $30-90^{\circ}$  grazing angle range of the data.

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